

FINAL REPORT

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NASA Grant NAGW 392: Dynamics of Satellites and Dust Particles

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(a) Objectives.

- (1) To investigate the dynamics of resonance, particularly temporary trapping and chaotic motion, in the satellite systems of Saturn and Uranus, in order to determine the orbital, internal, and thermal histories of the satellites.
- (2) To measure the shapes of satellites in order to place constraints on their mean densities and internal structures.
- (3) To investigate the orbital evolution of dust particles in the solar system in order to determine the origin of the dust particles in the zodiacal cloud, and to account for the IRAS dust band observations.

(b) Final Report of Work Done at Cornell University

The main achievements of this grant were:

1. We argued that Titan may have a deep hydrocarbon ocean and placed a lower bound on its depth from arguments based on tidal friction.
2. We showed that the Kirkwood gaps cannot be relics of some formation process but must be maintained by some ongoing dynamical process involving Jupiter.
3. We investigated the dynamics of narrow rings and showed that narrow rings may contain small satellites that maintain ring particles on horseshoe orbits.
4. We gave the first clear demonstration that the rotational periods of asteroids depend on both diameter and type.
5. We were the first to show that the colors of S-type asteroids vary with distance from the Sun.
6. We suggested, prior to Voyager's encounter with Uranus, that the motions of the satellites of Uranus could have been chaotic in the past and that this could have had interesting consequences for Miranda.

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7. We showed that the solar system dust bands discovered by IRAS are associated with the Hirayama asteroid families. This was the first evidence that asteroids are an important, and may be the dominant, source of particles for the zodiacal cloud.

8. Prior to Voyager's encounter with Uranus, we also showed that previous theories used to determine the masses of the Uranian satellites were completely wrong and that, at that time, the masses of the Uranian satellites were unknown. This was confirmed by Voyager.

9. We showed that the large scale structure of the solar system dust bands could be determined using secular perturbation theory and that this theory could be used to determine the location of the bands and the orbital elements of the dust particles.

10. We gave numerical and analytical arguments that demonstrated that the motions of the Uranian satellites were chaotic in the past and we showed that the 3:1 secondary resonance between Miranda and Umbriel was probably responsible for the high inclination of Miranda's orbit.

11. We showed that the shape of Mimas was a triaxial ellipsoid and used the shape to determine the internal structure of the satellite. This work was the first determination of the internal structure of a satellite in the solar system other than the Moon.

Papers Published under NASA Grant NAGW-392

Principal Investigator: Professor S. F. Dermott

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